DEEP UNDERGROUND MINING: APPROPRIATE TECHNOLIGIES FOR VIETNAM

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Introduction

Taiheiyo coal mine is located in Kushiro City in the eastern part of Japan's northernmost island, Hokkaido. It is an undersea coal mine with an annual production of around 2.1 million tons of steaming coal mined from the bottom of the Pacific Ocean. The geological structure is basically monoclinal and the coal seam runs from northeast to southwest, from the coastline to offshore, with a declivity of –6°. The present area of operation is around 700m below sea level at the deepest point, and there are four large 50 100m faults which divide mining area into 5 blocks, as well as many smaller faults. The sea depth is approximately 10% of the mining area depth. The mine opening is an inclined shaft method, which is the most suitable for the geological structure of the area. The mine structure is a combination of inclined shafts and horizontal roadway, and in its 80 years of operation since the opening in 1920, the area of operations has expanded to an area of 10km in the west-east direction and 8km in the north-south direction, with a total roadway length of 200km. Expansion of the road way network in the mining area has meant expansion further offshore and to deeper regions, which has entailed increased costs in haulage, ventilation and drainage, etc. While basic improvement of undersea mining operation using offshore vertical shafts is difficult, the company has worked to improve efficiency and reduce costs through improvement of the production structure in terms of both technical and labor aspects. Taiheiyo coal mine introduced the mechanized longwall mining method using the drum shearer and shield supports in 1967. We named this method SD-mining, which is the method in general use throughout the world now. We have managed to increase productivity through the implementation of the various improvements to the SD-mining method. We believe that the reason why Taiheiyo coal mine has been able to technical and safety improvements in mine. However, the situation we face now is much more severe, requiring strict rationalization policies. Here, we would like to report on the results so far seen in our rationalization through improvements in the mining operations.

Transaction in deep underground mining operations

Since the opening, Taiheiyo coal mine has continued the operation in underground; the mining area has expanded year by year and becoming progressively deeper. Up until the full-scale changeover to undersea mining in 1951,the mining operations were carried out in shore, support system was T-support in timber, and the mining was carried out in coal pick with blasting. The average depth of mining area was shallower than -150m from ground level and supporting force was around 10 tons. After 1951, we started employ the steel prop with link bar to the depth of -200m from the sea level. Up until the 1960's, mining operations were carried out in the left and right of the Harutori inclined shaft. The Harutori shaft runs from the mine entrance to the center of the mining area, with a total distance of 3,000m and an average declivity of –6°. At that time, mining operations were concentrated at the No.5 main roadway, which runs horizontally at a depth of –320m in an east-west direction from the bottom of the Harutori inclined shaft and also we started SD- mining method with OMKT support system in 1967. For future development of the mining operation area, roadway driving has been carried out in which lies under the No.5 roadway. In 1972, we employed TY-1 type support system, which has 400tons supporting forth at the depth of –500m mining area. The No.2 inclined shaft, which was completed in 1978, has a total length of 4,000m and an average declivity of –5°, and connects the No.5 truck roadway with the No.7 truck roadway which lies –650m level. In 1982, driving started on the No.8 roadway, which would be a trunk roadway in the future, development of the area under the No.7 truck roadway. In 1989, we employed NT-6 type support system, which has 600tons supporting forth at the depth of –600m. Continued expansion of the mining area meant that the roadway network has become deeper, more expansive, and more complex. This has led to various problems and increased the costs of mining operations for the company. The deeper operation area has meant an increase in roadway maintenance work due to the increase in ground pressure. The present time, we are employing TH-7 type support system, which has 738tons supporting forth at the depth of –700m from the sea level. The longer distances have meant an increase in haulage operations, longer transport time for workers, which has reduced working time, and an increase in ventilation cost. The best solution for there problems is to undertake a basic restructuring of the mining network, by sinking offshore vertical shafts linking the nearest point of the mining area to the surface. However, high waves and the relatively deep sea level makes the sinking of offshore vertical shafts difficult, and we must explore other ways for solving the above problems. The most practical and sound solution for the above problems is to implement measures for greatly improving the production efficiency at the mining site, and concentrate the mining operations in a small area. Developments in the SD mining method is one example of our company's efforts at technical improvements in order to increase productivity. However, as the mining operation area includes only 3 recoverable coal seams and many faults, large extractions from single panel are impossible, which means the concentration of mining operations into a small area is difficult. Thus, we have been studying alternative ways for improving the mine structure.

Improvements in the Transportation system for men and materials

In the former transportation system, the workers must take three trains to reach their working places, which takes around 1 hour. A staggered work shift system for workers has been used for many years as a solution for this problem, and in Taiheiyo coal mine's mining operations, we have divided the 3 shifts into a further two groups, making a total of 6 groups, which enter the mine at different times. However, the further offshore the mine expands, the less the effective working time for each worker becomes, which was a big problem for Taiheiyo coal mine. The solution we have considered for this problem was to combine the transport routes into one high-speed transport train in the No.6 roadway. Also, to make this even more effective, we decided to combine 2 inclined shaft into one shaft, and introduce the newly developed high-speed winder.

Improvements in the Ventilation system

As the mine network has become progressively deeper, expansive and complex, ventilation requirements have also increased. For measures to prevent spontaneous combustion, the standard operating pressure for fans used in our mine is set at a maximum 300mmAq, which means that ventilation by a main fan only is impossible. Booster fans and a series of auxiliary fans provide sufficient ventilation at the working site in our mine. The present total upcast is 20,000m3/min and the total pressure requirement is around 500mmAq. The total output of all fans is around 3,000kw, which are approximately 25% of the total power requirements for the mine.In order to meet the ventilation requirements, we had constructed a new shaft to improve the ventilation system.The sinking of a new ventilation shaft was begun in 1983 at the west edge of the coast, where is the nearest point on the ground from existing mining area. The ventilation shaft was completed in 1984, and a 730kw-turbo fan was installed at the entrance. In 1990, the diagonal ventilation system was completed with the conversion of several upcast and downcast shafts. We intended to employ diagonal ventilation system for the purpose of improving mine safety.

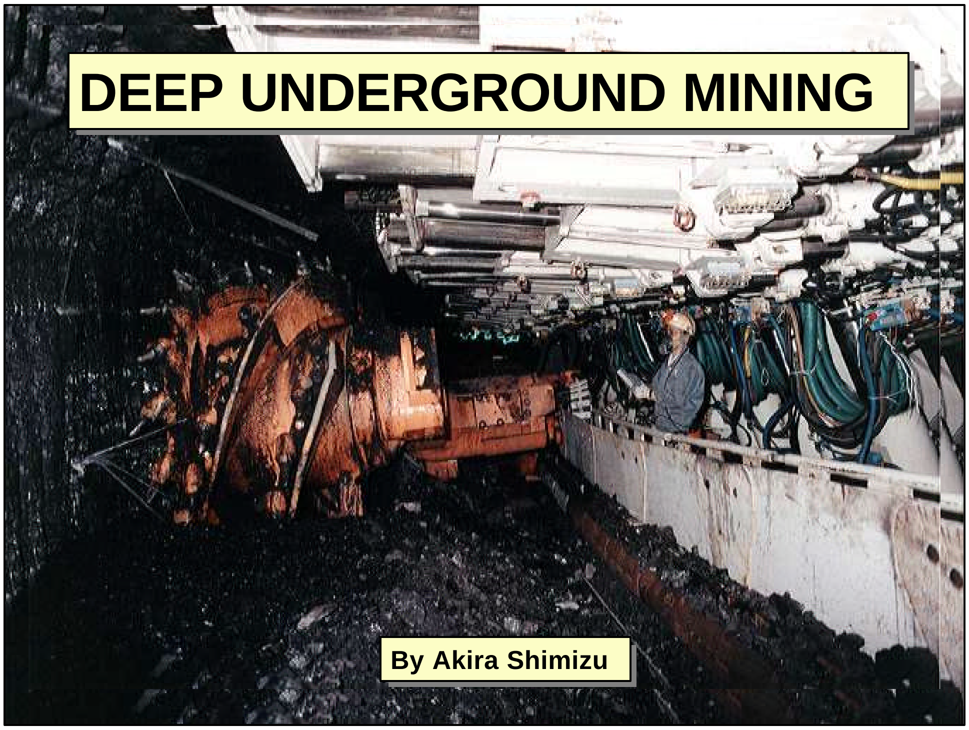
Introduction of the safety monitoring system

In Taiheiyo coal mine, staff on the ground has continuously monitored the presence of methane and other safety factors. However, as the mine network has become more expansive and complex, with only a small number of monitoring and patrol staff, it has become necessary to improve the technology of the central monitoring system for the purpose of improving mine safety. Work started in 1986 on the design of a new high-tech safety monitoring system. The new system displays a 1 to 1,000 scale layout of the mine network with symbols representing the various properties of the mine, and monitors over 1,000 points, including analog data from methane and CO sensors, machine

ON-OFF modes, etc. This information is continuously monitored on a 70-inch screen and desk monitor in the control room. Also, this system uses an optical fiber system for the transmission of information. The optical fiber system is very reliable system and will also be able to handle increases in information in the feature. Reduction of the 1 to 1,000 scale layouts of the mine network can easily and quickly be produced, which is useful for producing various color maps of the mine network showing different information.

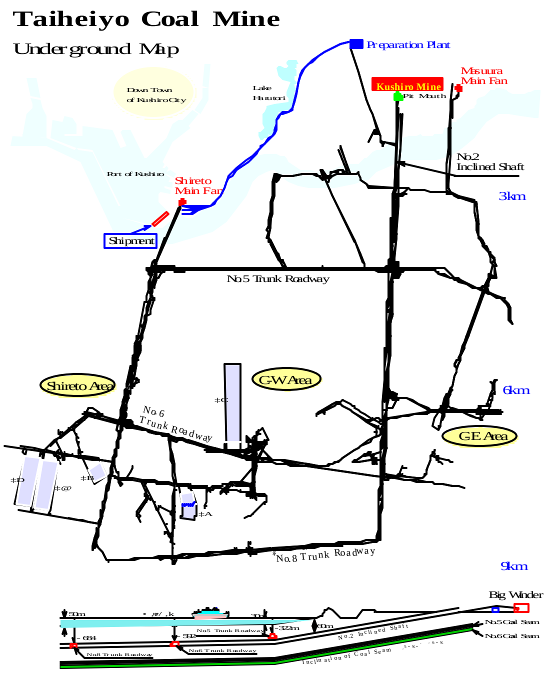
Conclusion

The deep underground mining operations becomes very difficult as the mining network expands and leads to an increase in transportation distances, increased costs due to the decrease in actual working time, and increased power requirements for a larger ventilation system. Taiheiyo coal mine, in an effort to increase productivity under the above conditions, has carried out major restructuring of the mine, including further mechanization and rationalization of mining methods, as well as improvements in the mine structure, such as transportation, ventilation and safety monitoring systems. However, despite all of the improvements to the mine, high operating costs still make it impossible for us to operate without policy support from the government. As the yen has become higher, the price gap between domestic and imported coal has become progressively larger. However, as coal is still an important energy source for Japan, we believe that we should strive to maintain the highest possible level of self-sufficiency in coal. It is the intention of our company to continue to carry out improvements to the best of our ability and thereby try to reduce production costs and to improve mine safety, in order to maintains our coal production. Lastly, we hope that the experiences in Taiheiyo coal mine will be a help to a mine or project which faced to the same problem under the deep underground mining operation, such as a "Red River project" in Vietnam.

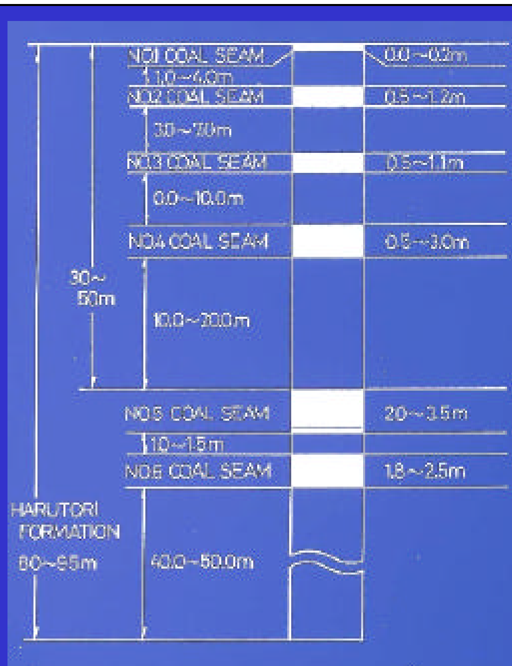


GENERAL MINING CONDITION

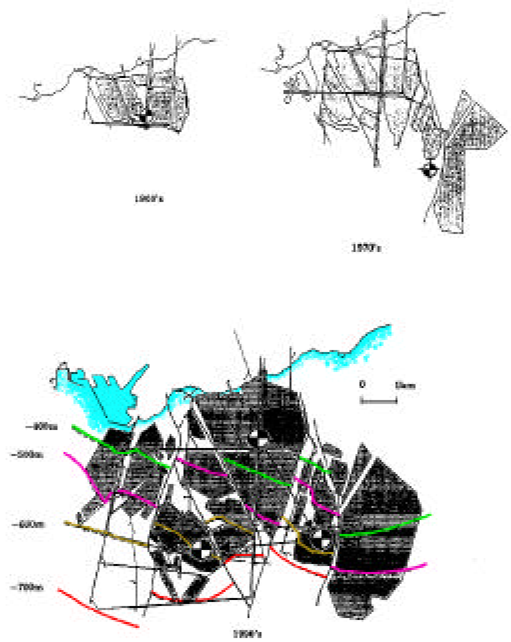
- **Production**
  210ton/year
- **Undersea and Deep Mine**
  10km offshore and mining depth around -700m at deepest point
- **Tertiary Coal Bearing Formation**
  Generally soft roof and floor
- **Complex in the geological structure**
  Many faults exists ranging from seem thickness around 3m to more than 100m
- **High ash contents**
- **Gassy**



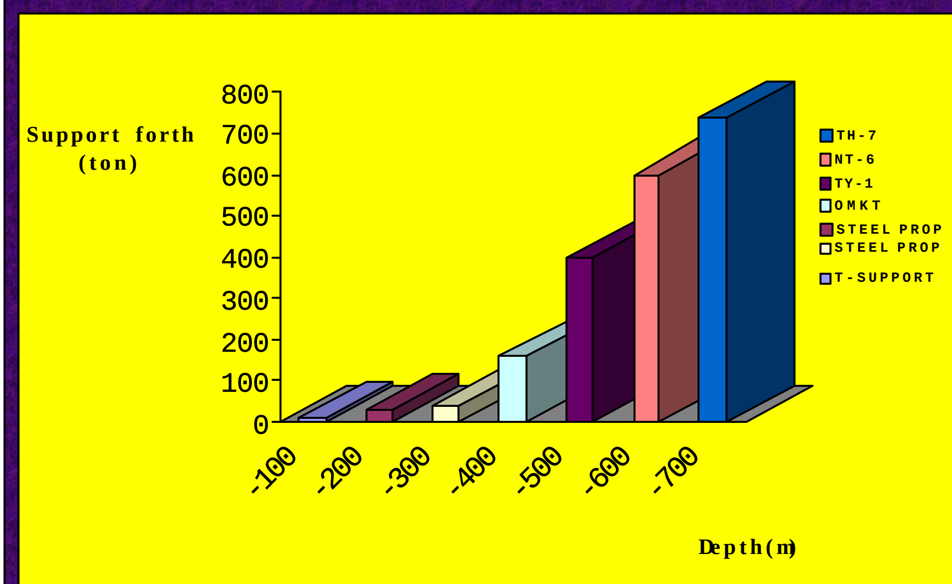
Underground Map



General HARUTORI Formation



The expansion and deepening of the operation area and the shift in the center of operations



Supporting forth and Depth

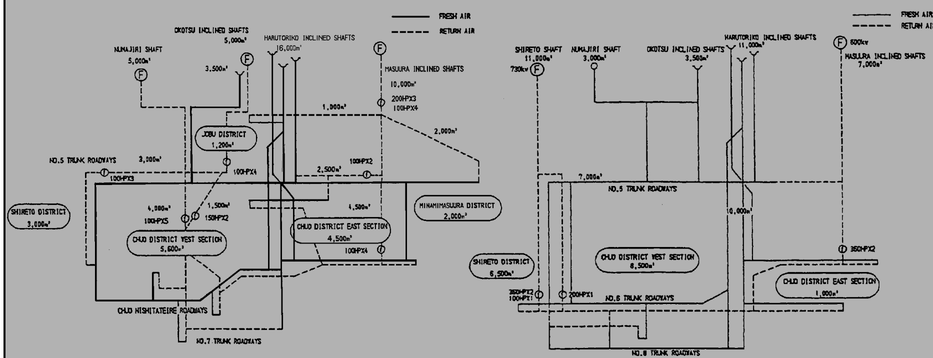
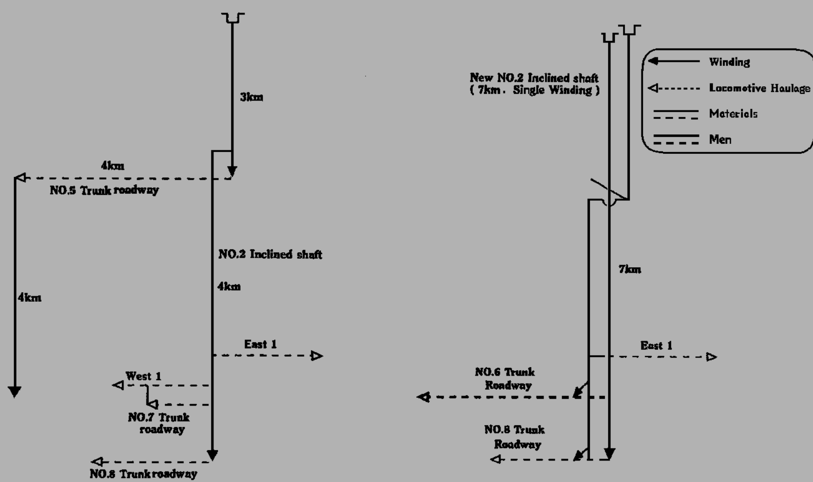


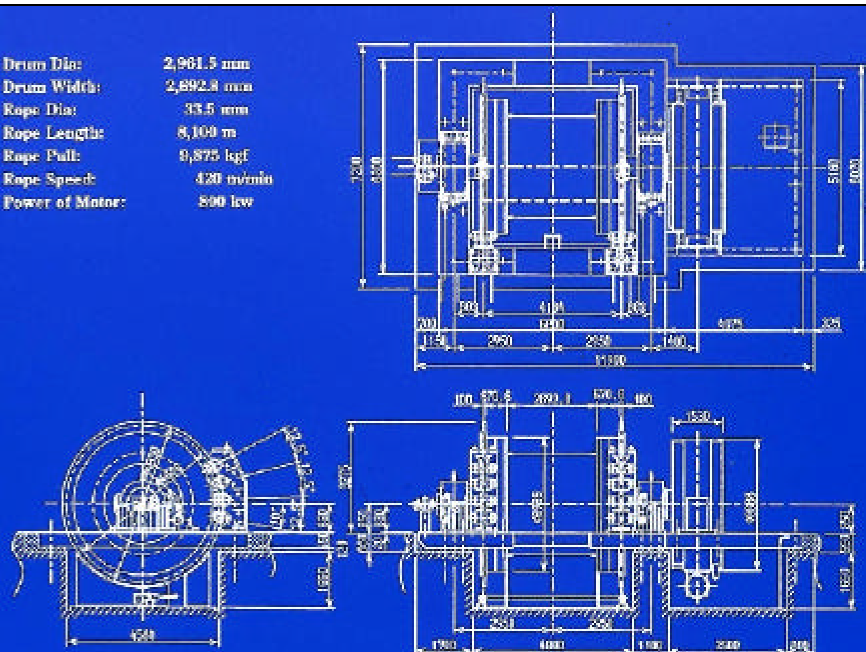
Diagram of the former and new Ventilation System

Main Fan (Shireto)



Former and New Transportation System

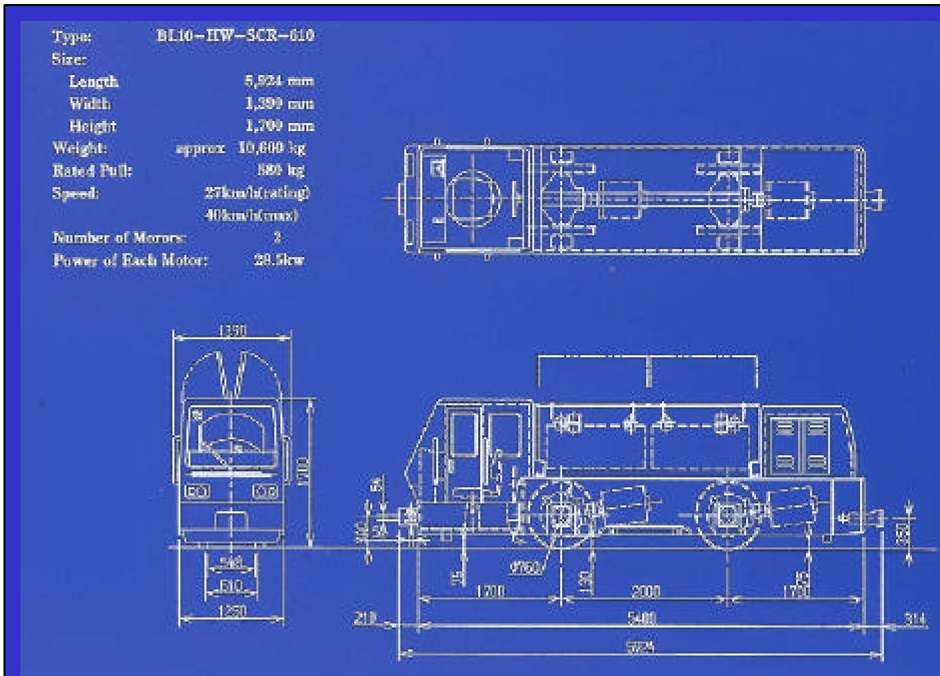
Drum Dia:	2,961.5 mm
Drum Width:	2,692.8 mm
Rope Dia:	33.5 mm
Rope Length:	8,100 m
Rope Pull:	9,875 kgf
Rope Speed:	420 m/min
Power of Motor:	800 kw



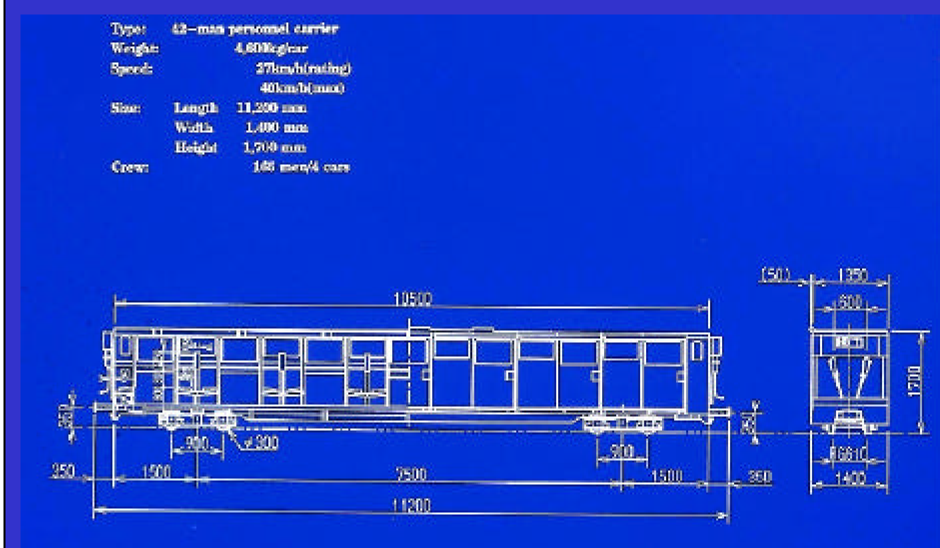
Specification of the New Winder

High-speed Winder

Transportation Car (inclined shaft)



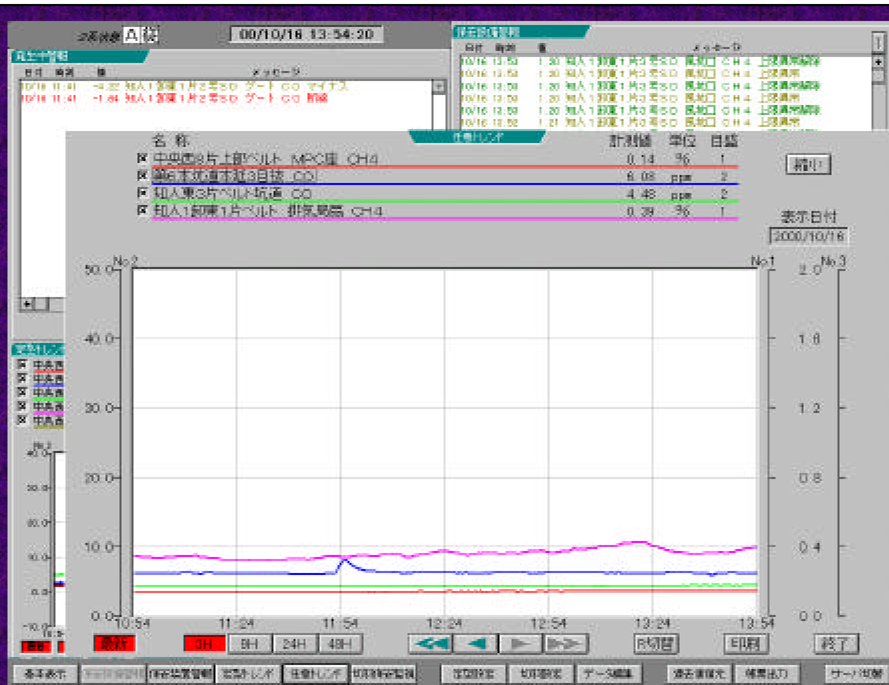
Specification of High-speed Battery Powered Locomotive



Specifications of Personnel Carrier

High-speed Transport Train

Monitoring Room



Indication of Trend graph